Dynamically Adjusting the Distribution for Dispatching Lot Between Current and Downstream Tool by Using Expertise W ighting M chanism

Background of the Invention

5 **Field of the Invention**

[0001]   This invention relates generally to manufacturing systems. More particularly, this invention relates to computer integrated manufacturing systems that dynamically dispatches product lots for fabrication to subsequent equipment in a manufacturing line.

10 **Description of Related Art**

[0002]   In competitive manufacturing environments such as fabrication of electronic integrated circuits on substrates, delivery to a committed schedule is one of the most important factors to the operation of the enterprise. However, the tool utilization and quality of the fabrication of the product are almost equally

15   important. The balancing of the loading of equipment or tooling of the various stages of the manufacturing lines of the enterprise must be considered.

[0003]   Often to accommodate a "hot lot" or a lot having a very high priority for fabrication, the necessary manufacturing equipment may be idled or have its scheduling minimized to allow acceptance of the "hot lot" upon arrival. In other

20   instances, the operators may not have a complete understanding of the flow of the product through the manufacturing line and may cause certain equipment to

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lack product lots for processing or may cause other equipment to have a backlog or long queue of product waiting for the equipment. Supervisors generally observe multiple units or pieces of manufacturing equipment within the manufacturing line and are able to determine if there is no queue or a too long a queue for individual pieces of equipment. The supervisors then communicate changes in the priorities of the lots set for processing in an attempt to adjust the distribution of the queues of the manufacturing equipment.

[0004]   The operators must then interpret the instructions of the supervisors to attempt to adjust the distribution of the product lots for processing. Often there is a misunderstanding or miscommunication between an operator and the supervisor or the operator makes a mistake in the operation of the equipment. The operator does not react quickly to the instruction or does not comprehend the instructions and the fabrication of the product is further delayed.

[0005]   "Understanding the Fundamentals of Kanban and Conwip Pull Systems Using Simulation", Marek, et al., Proceedings of the 2001 Winter Simulation Conference, pp: 921-929, found www.informs-cs.org, 6/21/03 This paper presents an introductory overview and tutorial in simulation modeling and control of serial Kanban and CONWIP (CONstant Work In Process) pull systems using ARENA/SIMAN 3.5/4.0.

[0006]   U. S. Patent 6,564,113 (Barto, et al.), describes a Lot start agent that calculates virtual WIP time in a multi-product and multi-bottleneck manufacturing environment. A system and method are provided for calculating virtual WIP time

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("VWIP"). The system and method provide for the calculation of one or more bottleneck VWIP values.

[0007]   U. S. Patent 6,470,227 (Rangachari, et al.), describes a method and the apparatus for automating a microelectric manufacturing process by configuring application objects that implement a domain knowledge for a piece of equipment and then implementing a workflow. The method is embodied in a computer program that is part of a computer system.

[0008]   U. S. Patent 6,259,959 (Martin) describes a method for determining the performance components of a manufacturing line. A process for optimizing a manufacturing line including raw processing times of a plurality of work centers; summing the work center raw processing times, determining work center cycle times, dividing the work center cycle times by respective ones.

[0009]   U. S. Patent 6,128,588 (Chacon) describes an integrated wafer fab time standard (machine tact) database. An integrated wafer fab production characterization and scheduling system incorporates a manufacturing execution system with a scheduling system based on simulation. The system provides a simulation tool integrated with the manufacturing execution system to evaluate proposed production control logic. Also included are: integration of preventive maintenance scheduling, Kanban based WIP control, an integrated time standard database, and real time lot move updates.

[0010]   U. S. Patent 5,826,238 (Chen, et al.) describes a method and system that operates a data processing system. This includes a data base computer system and a resource allocation computer for control of resource allocation. The method has several steps including: deriving data from the storage means and computing the targets for each of the stages; obtaining machine capacity data from the data storage means and employing the machine capacity data for allocating machine capacity proportionally and adjusting targets.

[0011]   U. S. Patent 5,768,133 (Chen, et al.) describes a WIP/move management tool for semiconductor manufacturing plant and method of operation thereof. This interactive data processing system and/or method is a management tool for a manufacturing plant including a shop floor control system. A server contains a data engine for extracting data, a load and transform data unit, and a database management storage unit. The database management storage unit supplies data to an interactive graphic user interface.

Summary of the Invention

[0012]   An object of this invention is to provide a system and method that prioritizes product lots for fabrication and dispatching to manufacturing equipment.

[0013]   Another object of this invention is to provide a system and method that establishes a priority for dispatching product lots to manufacturing equipment

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based on a criticality factor of manufacturing equipment following the current equipment.

[0014]   Further, another object of this invention is to provide a system and method that establishes a priority for dispatching product lots to manufacturing equipment based on a processing capability and efficiency of manufacturing equipment following the current equipment. The manufacturing equipment for example is equipment used for fabricating integrated circuits upon a substrate. This equipment includes semiconductor wafer cleaning equipment and furnaces used for processing the substrates to fabricate the integrated circuits.

[0015]   To accomplish at least one of these objects, a computer integrated manufacturing system executes program processes that function as a lot dispatcher and a priority factor calculator. The lot dispatcher is in communication with an order entry system in order to receive requests for the fabrication of a product lot. The lot dispatcher is further in communication with a process information system to receive procedures defining which manufacturing equipment is required for the fabrication of the product lot. A manufacturing information system provides the lot dispatcher with the status of the fabrication of the product lot, a criticality factor for each piece of manufacturing equipment, and a queue level for each piece of manufacturing equipment that follows a current group of pieces of manufacturing equipment required for the product lot.

[0016]   The priority factor calculator is in communication with the lot dispatcher to receive a listing of the manufacturing equipment required for the fabrication of

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product, the criticality factor of the manufacturing equipment, the processing capacity of the manufacturing equipment, the efficiency of the manufacturing equipment, and the queue level. The priority factor calculator then determines a Kanban factor or priority factor for the product lot such that each group of pieces of manufacturing equipment following the current group of pieces of manufacturing equipment has a balanced loading and the product lot is processed at an expeditious time for on-time delivery.

[0017]   The priority factor calculator determines the Kanban or priority factor based on the criticality factor and the types of equipment employed in the following steps of the process for fabricating the product lots. The priority factor is calculated at a first level when groups of first following pieces of manufacturing equipment have a criticality factor of a first level. Alternately, the priority factor is calculated at a second level when groups of first following pieces of manufacturing equipment are of a first type and if groups of second following pieces of manufacturing equipment are of a second type.

[0018]   The magnitudes of the first and second priority levels as calculated determine whether the product lots are dispatched immediately with a higher priority or are placed on the queue and handled in normal order. If the magnitude of the first priority level achieves a threshold level, the product lot is immediately dispatched for processing. On the other hand, if the second priority level achieves the threshold level, the product lot is immediately dispatched for processing.

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[0019]   The priority factor calculator determines the first priority factor level by the

formula:

$$KF\_1 = \frac{WIP\_c}{TOOL\#\_c * PPH\_c * EFF\_c}$$

where:

KF_1 is the first priority level for of a product lot entering a group of

current pieces of manufacturing equipment

WIP_c is a number of items within all product lots in a queue for the

group of first following pieces of manufacturing equipment,

TOOL#_c is the number of pieces of equipment within a group of

the first following pieces of manufacturing equipment;

PPH_c is the average number of items of product capable of being

manufactured by the group of the first following pieces of

manufacturing equipment,

EFF_c is an efficiency factor for the group of the first following

pieces of manufacturing equipment.

[0020] The priority factor calculator determines the second priority level by the formula:

$$KF\_2 = \frac{WIP\_cd + INPR\_cd + WIP\_d}{TOOL\#\_d * PPH\_d * EFF\_d}$$

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where:

KF_2 is the second priority level for of a product lot entering a current group of pieces of manufacturing equipment

WIP_cd is a number of items within all product lots in a queue for the group of first following pieces of manufacturing equipment and the group of second following pieces of manufacturing equipment,

INPR_cd is a number of items within all product lots in a queue for the group of first following pieces of manufacturing equipment which are to proceed subsequently to the group of second following pieces of manufacturing equipment,

WIP_d is a number of items within all product lots in a queue for the group of second following pieces of manufacturing equipment,

TOOL#_d is the number of pieces of equipment within a group of the second following pieces of manufacturing equipment;

PPH_d is the average number of items of product capable being manufactured by the group of the second following pieces of manufacturing equipment,

EFF_d is an efficiency factor for the group of the second following pieces of manufacturing equipment.

[0021]   If the group of first following pieces of manufacturing equipment has a criticality factor of a second level, the priority factor has a third priority level, which indicates that the product lot should not be dispatched immediately for processing and the product lot is placed on a queue of one of the first following pieces of manufacturing equipment. Similarly, if the group of first following pieces of manufacturing equipment is not of the first type, the priority factor has a fourth priority level, which indicates that the product lot should not be dispatched immediately for processing and the product lot is placed on a queue of one of the first following pieces of manufacturing equipment. Also, similarly, if the group of second following pieces of manufacturing equipment are not of the second type, the priority factor has a fifth priority level, which indicates that the product lot should not be immediately dispatched for processing and the product lot is placed on one queue of one of the first following pieces of manufacturing equipment. Finally, if the group of first following pieces of manufacturing equipment is of the first type, and the group of second following pieces of manufacturing equipment is of the second type, and the group of second following pieces of manufacturing equipment has a criticality factor that is not the first level, the priority factor has a sixth priority level. The sixth priority level indicates that the product lot should not be dispatched immediately for processing and the product lot is placed on a queue of one of the first following pieces of manufacturing equipment.

Brief Description of the Drawings

[0022]   Fig. 1 is a diagram illustrating a manufacturing enterprise with a computer

integrated manufacturing system that provides a product lot dispatching system

of this invention.

5   [0023]   Fig. 2 is an example of a routing diagram illustrating the status and factors

of the manufacturing equipment to be employed in the fabrication of particular

product lots that provide the necessary information for the determining of a

Kanban or priority factor of this invention.

[0024]   Fig. 3 is a flow chart of the method for determining the priority for

10   dynamically dispatching product lots to manufacturing equipment of this

invention.

Detailed Description of the Invention

[0025]   In order to provide fabrication of product lots from a manufacturing line

within an enterprise to meet committed schedules, the lots must be scheduled to

15   dispatch each tool or piece of manufacturing equipment expeditiously. Further,

to avoid having either long waiting or queuing times and having pieces of

manufacturing equipment that are "starving" or have no queue, the scheduling

must account for both the amount of product to be immediately processed and

the capacity, capability, and present queue length of pieces of manufacturing

20   equipment following the current piece of manufacturing equipment.

[0026]   Refer now to Fig. 1 for a description of a manufacturing enterprise that dispatches product lots to the pieces of manufacturing equipment using the dispatching system of this invention. The manufacturing enterprise has multiple manufacturing lines **5** and **10**. In the example of an integrated circuits manufacturing enterprise, each manufacturing line **5** and **10** is a semiconductor processing line.

[0027]   The manufacturing lines **5** and **10** each have a series of workstations or manufacturing stages **15a**, **15b**, ..., **15n** and **25a**, **25b**, ..., **25n**. Each of the manufacturing stages **15a**, **15b**, ..., **15n** and **25a**, **25b**, ..., **25n** has multiple tools or pieces of manufacturing equipment each of which perform various processes in the fabrication of the product lots. In the capital intensive operation, as in the integrated circuit fabrication example, many of the pieces of manufacturing equipment are extremely expensive and must be utilized to their fullest. However, as noted before, those product lots that have a high priority for delivery must be processed expeditiously to meet the committed schedules.

[0028]   Each of the pieces of manufacturing equipment within each of the manufacturing stages **15a**, **15b**, ..., **15n** and **25a**, **25b**, ..., **25n** is in communication with the manufacturing execution systems **20a**, ..., **20n**. The manufacturing execution systems **20a**, ..., **20n** provide control and scheduling for each of the manufacturing stages **15a**, **15b**, ..., **15n** and **25a**, **25b**, ..., **25n**. Further, the manufacturing stages **15a**, **15b**, ..., **15n** and **25a**, **25b**, ..., **25n** transmit a status of the product lot's progress or work-in-process (WIP) status

describing the advancing of the product lot through the manufacturing stages **15a**, **15b**, ..., **15n** or **25a**, **25b**, ..., **25n**.

[0029]   The manufacturing execution systems **20a**, ..., **20n** are in communication with the computer integrating network **30** which allows the manufacturing execution systems **20a**, ..., **20n** to communicate with the necessary control and information systems to allow for dispatch and scheduling of product lots to the manufacturing lines **5** and **10**.

[0030]   The dispatch system **35** has a lot dispatcher **50** and a Kanban factor calculator **55**. The lot dispatcher **50** is in communication with the order entry database **40** and the process information database **45**. The order entry database **40** provides a listing of the product lots to be fabricated. With the listing of the product lots are linkages or pointers to the process information database **45**. The process information database **45** provides a description of the recipe for the fabrication of the product and thus a process flow describing the required manufacturing equipment required to produce the product. The dispatch system **35** is further in communication with the manufacturing execution systems **20a**, ..., **20n** to receive the status of the fabrication of all product lots, a criticality factor for each piece of manufacturing equipment, and a queue level for each piece of manufacturing equipment.

[0031]   The lot dispatcher is in communication with the Kanban factor calculator **55** to provide the listing of product lots being fabricated, the order of the execution of the process necessary to produce the product lots and the

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manufacturing equipment used to perform the processes. The status of each lot,

the criticality factor of each piece of manufacturing equipment being employed in

the process of each product lot, and the queue level of each piece of

manufacturing equipment following the current piece of manufacturing equipment

5   processing each of the product lots. The Kanban factor then creates a measure

of the priority necessary to balance the loading such that the product lot is

processed at an expeditious time for on-time delivery.

[0032]   While one stage of the manufacturing stages **15a**, **15b**, ..., **15n** or **25a**,

25b, ..., **25n** is performing its step in the execution of the procedures for

10   fabrication of the product lot, the dispatch schedule for the next stage of the

product lot is determined by the method as shown in Fig. 2. The lot dispatcher

50 starts the evaluation (Box **100**) of the load balancing, efficiency, and capacity

by testing (Box **105**) the type of tool of a group of the pieces of manufacturing

equipment immediately following the piece of manufacturing equipment for which

15   the product lots are being scheduled. If the group of immediately following

pieces of manufacturing equipment is of a first type, in the example of the

integrated circuit processing, the type of manufacturing equipment could be a

cleaning tool that removes contaminants from substrates during the processing.

The lot dispatcher **50** then tests (Box **110**) the type of tool of the group of pieces

20   of manufacturing equipment that is the next following or third group of pieces of

manufacturing equipment following the piece of manufacturing equipment

executing is procedure for the fabrication of the product lot. In this instance, the

test (Box **110**) is to determine if the next following piece of manufacturing

equipment is of a second type. In the example of integrated circuit processing, the type of the piece of manufacturing equipment would be, for illustration, a processing furnace. The criticality factor the group of the next piece of equipment is evaluated (Box **115**), if either the group of the following pieces of manufacturing equipment is not of the first type or the group of next following pieces of manufacturing equipment is not of the second type. If the criticality factor the group of the following pieces of manufacturing equipment is low and the group of the following pieces of equipment does not have an impact on the time for processing of the product lot, the Kanban factor is set (Box **125**) to zero.

[0033]   Alternately, if the criticality factor of the group of the following pieces of manufacturing equipment is high and the group of the following pieces of equipment has an impact upon the time to process of the product lot, the Kanban factor calculator **55** determines (Box **130**) a first priority or first Kanban level for the Kanban factor by the formula:

$$KF\_1 = \frac{WIP\_c}{TOOL\#\_c * PPH\_c * EFF\_c} \qquad (A)$$

where:

KF_1 is the first priority level or Kanban level for of a product lot entering a group of current pieces of manufacturing equipment.

WIP_c is a number of items within all product lots in queue for the group of first following pieces of manufacturing equipment.

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TOOL#_c is a number of pieced of equipment within a group of the first following pieces of manufacturing equipment.

PPH_c is the average number of items of product capable of being manufactured by each piece of the group of the first following pieces of manufacturing equipment. In the illustration the capability of the manufacturing equipment would be in wafers per hour or **(WPH)** for a piece of substrate cleaning equipment.

EFF_c is an efficiency factor for the group of the first following pieces of manufacturing equipment.

[0034] If the group of the following piece of manufacturing equipment is of the first type and the group of next following pieces of manufacturing equipment are of the second type, the criticality factor of the group of next following pieces of manufacturing equipment is evaluated (Box **120**). If the criticality factor of the group of next following pieces of manufacturing equipment is low and group of next following pieces of manufacturing equipment does not have an impact on the time for processing of the product lot, the Kanban factor is set (Box **150**) to zero.

[0035] On the other hand, if the criticality factor of the group of next following pieces of manufacturing equipment is high and group of next following pieces of manufacturing equipment has an impact upon the time for processing the product

lot, the Kanban factor calculator 55 determines the Kanban factor at a second

priority or Kanban level determined (Box 135) by the formula:

$$KF\_2 = \frac{WIP\_cd + INPR\_cd + WIP\_d}{TOOL\#\_d * PPH\_d * EFF\_d}$$

where:

5   KF_2 is the second priority or Kanban level for of a product lot

entering a current group of pieces of manufacturing equipment.

WIP_cd is a number of items within all product lots in queue for the

group of first following pieces of manufacturing equipment and

the group of second following pieces of manufacturing

10   equipment.

INPR_cd is a number of items within all product lots in queue for

the group of first following pieces of manufacturing equipment

which are to proceed subsequently to the group of second

following pieces of manufacturing equipment.

15   WIP_d is a number of items within all product lots in queue for the

group of second following pieces of manufacturing equipment.

TOOL#_d is a number of pieced of equipment within a group of the

second following pieces of manufacturing equipment.

PPH_d is the average number of items of product capable of being manufactured by the group of the second following pieces of manufacturing equipment. In the illustration the capability of the manufacturing equipment would be in wafers per hour or (**WPH**) for a piece of substrate cleaning equipment.

EFF_d is an efficiency factor for the group of the second following pieces of manufacturing equipment.

[0036]   Upon completion of the calculations of the Kanban factor at either the first priority level or second priority level, the lot dispatcher **50** test (Box **140**) the calculated Kanban factor for each of the product lots ready for dispatch to the next following group of pieces of manufacturing equipment. If the Kanban factor is greater than a threshold value, the lots are assigned (Box **145**) a high priority for dispatch. Alternately . if the Kanban factor is les than a threshold value, the lots are assigned (Box **150**) a low priority for dispatch. The lot dispatcher **50** then communicates a product lot dispatch instruction to each of the manufacturing execution systems **20a, ..., 20n** such that the product lots are appropriately dispatched (Box **155**) to pieces of manufacturing equipment within the manufacturing stages **15a, 15b, ..., 15n** or **25a, 25b, ..., 25n**.

[0037]   As would be understood by one skilled in the art, the lot dispatch system would be integrated and function as a program process within the manufacturing execution systems **20a, ..., 20n**. This program process may be incorporated within each of the manufacturing execution systems **20a, ..., 20n** or may, in a

separate server system, provide support for the manufacturing execution

systems **20a**, ..., **20n**. The program process, when executed, causes the

manufacturing execution system **20a**, ..., **20n** executing the process to function

as the dispatching system **35** as described. Further the program process is

5 encoded as program code executable by the computer systems of the

manufacturing execution systems **20a**, ..., **20n** and is stored on a data retention

media such as magnetic or optical disks, random access memory, or read only

memory.

[0038]   The manufacturing execution systems **20a**, ..., **20n** maintain a

10 manufacturing information database as shown in Fig. 3, and provide the

appropriate product lot status and criticality factor to the dispatch system **35**. The

manufacturing information database **200** illustrates the routing for each product

lot as it progresses through the pieces of equipment of each of the manufacturing

stages **15a**, **15b**, ..., **15n** or **25a**, **25b**, ..., **25n**. The stage number is the

15 designator for each manufacturing stage **15a**, **15b**, ..., **15n** or **25a**, **25b**, ..., **25n**

through which a given product lot is to progress. In the illustration shown, the

product lot is in one of the pieces of equipment of the manufacturing stage **210**

designated *100*. The database **200** shows the dispatch view **215** and the lot view

220. The dispatch view **215** exemplifies the lot dispatcher view where current

20 tool (*200*) is the piece or group of pieces of manufacturing equipment that is to

receive the product lot or lots upon completion. The downstream tools are the

following and next following pieces of manufacturing equipment in the succession

of the process of the product lot. The lot view **220** shows the location of the

product lot within each stage or the manufacturing stages **15a**, **15b**, ..., **15n** or

25a, **25b**, ..., **25n**. The current tool **221** is performing the operation necessary

for the current step of the process for the fabrication of the product lot. For

instance, in an integrated circuit fabrication, if the piece of manufacturing

5   equipment is a cleaning tool, the substrate will have contaminants and undesired

process material removed. Alternately, if the piece of manufacturing equipment

is a furnace, the substrate is subjected to an operation such as diffusion of

material into the surface of the substrate. The next tool **222** is following in the

process for which the dispatch schedule is being created. The next two tools **223**

10   and **224** are the subsequent tools for which their capabilities, capacities, and

queues are to be balanced in the dispatch the next tool **222**. The tool

identification **225** provides the designation of the group of pieces of

manufacturing equipment that is required in the recipe of the process for the

product lot. The criticality factor **230** is a designation of the impact of the usage

15   of the piece of manufacturing equipment on the time involved to process the

product lot and the impact the piece of equipment has on in the flow of product

lots through the manufacturing lines **5** and **10**. In this example there are two

criticality levels, none or the group of pieces of manufacturing equipment does

not have an impact on the processing time as indicated by a blank entry. The

20   group of pieces of manufacturing equipment may be critical to the processing of

the product lot as indicated by the **Y**. Alternately, if there is a long queue of

product lots waiting for the particular piece of manufacturing equipment, the

whole manufacturing line **5** or **10** may be slowed, thus delaying delivery of product lots in a timely fashion.

[0039]   While this invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made without departing from the spirit and scope of the invention.

[0040]   The invention claimed is:

1   1.   A system for dispatching of at least one product lot for processing to

2   manufacturing equipment within processing stages of a manufacturing line, said

3   system comprising:

4   a lot dispatcher in communication with an order entry system to receive

5   requests for fabrication of a product lot, in communication with a

6   process information system to receive procedures defining which

7   manufacturing equipment is required for said fabrication of said

8   product lot, and in communication with a manufacturing information

9   system to receive a status of said fabrication of said product lot, a

10   criticality factor for each piece of manufacturing equipment, and a

11   queue level for each piece manufacturing equipment that follows a

12   current group of pieces of manufacturing equipment required for said

13   product lot; and

14   a priority factor calculator in communication with said lot dispatcher to

15   receive a listing of said manufacturing equipment required for said

16   fabrication of product, said criticality factor, and said queue level, for

17   determining a priority factor for said product lot such that each group of

18   pieces of manufacturing equipment following said current group of

19   pieces of manufacturing equipment has a balanced loading and said

20   product lot is processed at an expeditious time for on-time delivery.

1   2.   The system for dispatching of claim 1 wherein:

2   if groups of first following pieces of manufacturing equipment have a

3   criticality factor of a first level, said priority factor has a first priority

4   level, and

5   if groups of first following pieces of manufacturing equipment are of a first

6   type and if groups of second following pieces of manufacturing

7   equipment are of a second type, said priority factor has a second

8   priority level.

1   3.   The system for dispatching of claim 2 wherein if a magnitude of said first priority

2   level achieves a threshold level, said product lot is immediately dispatched for

3   processing.

1   4.   The system for dispatching of claim 2 wherein if said second priority level

2   achieves the threshold level, said product lot is immediately dispatched for

3   processing.

1   5.   The system for dispatching of claim 2 wherein:

2   said priority factor calculator determines said first priority factor level by

3   the formula:

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$$KF\_1 = \frac{WIP\_c}{TOOL\#\_c * PPH\_c * EFF\_c}$$

5   where:

6   **KF_1** is said first priority level for a product lot entering a group

7   of current pieces of manufacturing equipment

8   **WIP_c** is a number of items within all product lots in a queue for

9   the group of first following pieces of manufacturing

10   equipment,

11   **TOOL#_c** is a number of pieces of equipment within a group of

12   the first following pieces of manufacturing equipment;

13   **PPH_c** is an average number of items of product capable of

14   being manufactured by said group of the first following

15   pieces of manufacturing equipment,

16   **EFF_c** is an efficiency factor for said group of the first following

17   pieces of manufacturing equipment.

1   6.   The system for dispatching of claim 2 wherein:

2   said priority factor calculator determines said second priority level by the

3   formula:

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$$KF\_2 = \frac{WIP\_cd + INPR\_cd + WIP\_d}{TOOL\#\_d * PPH\_d * EFF\_d}$$

5   where:

6   KF_2 is said second priority level for a product lot entering a

7   current group of pieces of manufacturing equipment

8   WIP_cd is a number of items within all product lots in queue for

9   the group of first following pieces of manufacturing

10   equipment and the group of second following pieces of

11   manufacturing equipment,

12   INPR_cd is a number of items within all product lots in queue

13   for the group of first following pieces of manufacturing

14   equipment which are to proceed subsequently to the group

15   of second following pieces of manufacturing equipment,

16   WIP_d is a number of items within all product lots in queue for

17   the group of second following pieces of manufacturing

18   equipment,

19   TOOL#_d is number of pieces of equipment within a group of

20   the second following pieces of manufacturing equipment;

21   PPH_d is an average number of items of product capable of

22   being manufactured by said group of the second following

23   pieces of manufacturing equipment,

24   EFF_d is an efficiency factor for said group of the second

25   following pieces of manufacturing equipment.

1   7.   The system for dispatching of claim 2 wherein if the group of first following pieces

2   of manufacturing equipment has a criticality factor of a second level, said priority

3   factor has a third priority level.

1   8.   The system for dispatching of claim 7 wherein if said third priority level indicates

2   that said product lot should not be immediately dispatched for processing, said

3   product lot is placed on the queue of one of the first following pieces of

4   manufacturing equipment.

5   9.   The system for dispatching of claim 2 wherein if the group of first following pieces

6   of manufacturing equipment is not of the first type, said priority factor has a fourth

7   priority level.

1   10.   The system for dispatching of claim 9 wherein if said fourth priority level indicates

2   that said product lot should not be immediately dispatched for processing, said

3   product lot is placed on one queue of one of the first following pieces of

4   manufacturing equipment.

1   11.   The system for dispatching of claim 2 wherein if the group of second following

2   pieces of manufacturing equipment is not of the second type, said priority factor

3   has a fifth priority level.

1   12.   The system for dispatching of claim 11 wherein if said fifth priority level indicates

2   that said product lot should not be immediately dispatched for processing, said

3   product lot is placed on the queue of one of the first following pieces of

4   manufacturing equipment.

1   13.   The system for dispatching of claim 2 wherein if the group of first following pieces

2   of manufacturing equipment is of the first type, and the group of second following

3   pieces of manufacturing equipment is of the second type, and the group of

4   second following pieces of manufacturing equipment has a criticality factor that is

5   not the first level, said priority factor has a sixth priority level.

1   14.   The system for dispatching of claim 13 wherein if said sixth priority level indicates

2   that said product lot should not be immediately dispatched for processing, said

3   product lot is placed on the queue of one of the first following pieces of

4   manufacturing equipment.

1   15.   The system for dispatching of claim 1 wherein said product is substrates onto

2   which integrated circuits are fabricated.

1   16.   The system for dispatching of claim 1 wherein said manufacturing equipment is

2   integrated circuit processing equipment for the formation of integrated circuits

3   upon substrates.

1   17.   The system for dispatching of claim 1 wherein the integrated circuit processing

2   equipment includes furnaces and substrate cleaning equipment.

1   18.   A method for dispatching of at least one product lot for processing manufacturing

2   equipment within processing stages of a manufacturing line, said system

3   comprising the steps of:

4   receiving requests for fabrication of a product lot from an order entry

5   system;

6   receiving procedures defining which manufacturing equipment is required

7   for said fabrication of said product lot from a process information

8   system;

9   receiving a status of said fabrication of said product lot, a criticality factor

10   for each manufacturing equipment, and a queue level for each piece of

11   manufacturing equipment that follows a current group of pieces of

12   manufacturing equipment required for said product lot from a

13   manufacturing information system;

14   calculating a priority factor for said product lot from a listing of said

15   manufacturing equipment required for said fabrication of product, said

16   criticality factor, and said queue level,

17   balancing of loading of each group of pieces of manufacturing equipment

18   following said current group of pieces of manufacturing equipment from

19   said priority factor such that said product lot is processed at an

20   expeditious time for on-time delivery.

1   19.   The method for dispatching of claim 18 further comprising the steps of:

2   setting said priority factor to a first priority level, if groups of first following

3   pieces of manufacturing equipment have a criticality factor of a first

4   level, and

5   setting said priority factor has a second priority level, if groups of first

6   following pieces of manufacturing equipment are of a first type and if

7   groups of second following pieces of manufacturing equipment are of a

8   second type.

1   20.   The method for dispatching of claim 19 further comprising the step of dispatching

2   said product lot for processing, if a magnitude of said first priority level achieves a

3   threshold level.

1   21.   The method for dispatching of claim 19 further comprising the step of dispatching

2   said product lot for processing, if said second priority level achieves the threshold

3   level.

1   22.   The method for dispatching of claim 19 wherein:

2   calculating said priority factor comprises the step of determining said first

3   priority factor level by the formula:

$$KF\_1 = \frac{WIP\_c}{TOOL\#\_c * PPH\_c * EFF\_c}$$

5   where:

6   **KF_1** is said first priority level for a product lot entering a group

7   of current pieces of manufacturing equipment

8   **WIP_c** is a number of items within all product lots in queue for

9   the group of first following pieces of manufacturing

10   equipment,

11   **TOOL#_c** is a number of pieces of equipment within a group of

12   the first following pieces of manufacturing equipment;

13   **PPH_c** is an average number of items of product capable of

14   being manufactured by said group of the first following

15   pieces of manufacturing equipment,

16   **EFF_c** is an efficiency factor for said group of the first following

17   pieces of manufacturing equipment.

1   23.   The method for dispatching of claim 19 wherein:

2   calculating said priority factor comprises the step of determining said

3   second priority level by the formula:

4
$$KF\_2 = \frac{WIP\_cd + INPR\_cd + WIP\_d}{TOOL\#\_d * PPH\_d * EFF\_d}$$

5   where:

6   **KF_2** is said second priority level for a product lot entering a

7   current group of pieces of manufacturing equipment

8   **WIP_cd** is a number of items within all product lots in queue for

9   the group of first following pieces of manufacturing

10   equipment and the group of second following pieces of

11   manufacturing equipment,

12   **INPR_cd** is a number of items within all product lots in queue

13   for the group of first following pieces of manufacturing

14   equipment which are to proceed subsequently to the group

15   of second following pieces of manufacturing equipment,

16   **WIP_d** is a number of items within all product lots in queue for

17   the group of second following pieces of manufacturing

18   equipment,

19   **TOOL#_d** is number of pieces of equipment within a group of

20   the second following pieces of manufacturing equipment;

21   **PPH_d** is an average number of items of product capable of

22   being manufactured by said group of the second following

23   pieces of manufacturing equipment,

24   **EFF_d** is an efficiency factor for said group of the second

25   following pieces of manufacturing equipment.

1   24.   The method for dispatching of claim 19 wherein calculating said priority factor

2   comprises the step of setting said priority factor to a third priority level, if the

3   group of first following pieces of manufacturing equipment has a criticality factor

4   of a second level.

1   25.   The method for dispatching of claim 24 further comprising the step of placing

2   said product lot on the queue of one of the first following pieces of manufacturing

3   equipment, if said third priority level indicates that said product lot should not be

4   immediately dispatched for processing.

1   26.   The method for dispatching of claim 19 wherein if the group of first following

2   pieces of manufacturing equipment is not of the first type, said priority factor has

3   a fourth priority level.

1   27.   The method for dispatching of claim 26 further comprising the step of placing

2   said product lot on the queue of one of the first following pieces of manufacturing

3   equipment, if said fourth priority level indicates that said product lot should not be

4   immediately dispatched for processing.

1   28.   The method for dispatching of claim 19 wherein if the group of second following

2   pieces of manufacturing equipment is not of the second type, said priority factor

3   has a fifth priority level.

1   29.   The method for dispatching of claim 28 further comprising the step of placing

2   said product lot on the queue of one of the first following pieces of manufacturing

3   equipment, if said fifth priority level indicates that said product lot should not be

4   immediately dispatched for processing..

1 30.   The method for dispatching of claim 19 wherein if the group of first following

2   pieces of manufacturing equipment is of the first type, and the group of second

3   following pieces of manufacturing equipment is of the second type, and the group

4   of second following pieces of manufacturing equipment has a criticality factor that

5   is not the first level, said priority factor has a sixth priority level.

1 31.   The method for dispatching of claim 30 further comprising the step of placing

2   said product lot on the queue of one of the first following pieces of manufacturing

3   equipment, if said sixth priority level indicates that said product lot should not be

4   immediately dispatched for processing.

1 32.   The method for dispatching of claim 18 wherein said product is substrates onto

2   which integrated circuits are fabricated.

1 33.   The method for dispatching of claim 18 wherein said manufacturing equipment is

2   integrated circuit processing equipment for the formation of integrated circuits

3   upon substrates.

1 34.   The method for dispatching of claim 18 wherein the integrated circuit processing

2   equipment includes furnaces and substrate cleaning equipment.

1 35. An apparatus for dispatching at least one product lot for processing to

2 manufacturing equipment within processing stages of a manufacturing line, said

3 system comprising:

4   means for receiving to receive requests for fabrication of a product lot from

5   an order entry system;

6   means for receiving procedures defining which manufacturing equipment

7   is required for said fabrication of said product lot from a process

8   information system;

9   means for receiving a status of said fabrication of said product lot, a

10   criticality factor for each manufacturing equipment, and a queue level

11   for each piece manufacturing equipment that follows a current group of

12   pieces of manufacturing equipment required for said product lot from a

13   manufacturing information system;

14   means for calculating a priority factor for said product lot from a listing of

15   said manufacturing equipment required for said fabrication of product,

16   said criticality factor, and said queue level,

17   means for balancing the loading of each group of pieces of manufacturing

18   equipment following said current group of pieces of manufacturing

19   equipment from said priority factor such that said product lot is

20   processed at an expeditious time for on-time delivery.

1 36. The apparatus for dispatching of claim 35 further comprising:

2   means for setting said priority factor to a first priority level, if groups of first

3   following pieces of manufacturing equipment have a criticality factor of

4   a first level, and

5   means for setting said priority factor to a second priority level, if groups of

6   first following pieces of manufacturing equipment are of a first type and

7   if groups of second following pieces of manufacturing equipment are of

8   a second type.

1 37. The apparatus for dispatching of claim 36 further comprising means for

2   dispatching said product lot for processing, if a magnitude of said first priority

3   level achieves a threshold level.

1 38. The apparatus for dispatching of claim 36 further comprising means for

2   dispatching said product lot for processing, if said second priority level achieves

3   the threshold level.

1 39. The apparatus for dispatching of claim 36 wherein:

2   the means for calculating said priority factor comprises means for

3   determining said first priority factor level by the formula:

4
$$KF\_1 = \frac{WIP\_c}{TOOL\#\_c * PPH\_c * EFF\_c}$$